Appendix C - U.S. Geological Survey 2003 INEEL Publication Abstracts

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Field Methods and Quality-Assurance Plan for Quality-Of-Water Activities, U.S. Geological Survey, Idaho National Engineering and Environmental Laboratory, Idaho *(Bartholomay et. al. 2003)*

Water-quality activities at the Idaho National Engineering and Environmental Laboratory (INEEL) Project Office are part of the U.S. Geological Survey's (USGS) Water Resources Division mission of appraising the quantity and quality of the Nation's water resources. The activities are conducted in cooperation with the U.S. Department of Energy's (DOE) Idaho Operations Office and the U.S. Environment Protection Agency, Region 10. Results of the water-quality investigations are presented in various USGS publications or in referenced scientific journals. The results of the studies are highly regarded and are used with confidence by researchers, regulatory and managerial agencies, and interested civic groups.

In its broadest sense, quality assurance refers to doing the job right, the first time. It includes the functions of planning for products, review and acceptance of the products, and an audit designed to evaluate the system that produces the product. Quality assurance and quality control differ in that quality control ensures that things are done correctly given the "state-of-the-art" technology, and quality assurance ensures that quality control is maintained within specified limits.

Stage-Discharge Relations for Selected Culverts and Bridges in the Big Lost River Flood Plain at the Idaho National Engineering and Environmental Laboratory, Idaho *(Berenbrock and Doyle 2003)*

Information is needed by the DOE at the INEEL to determine the extent and severity of potential flooding at facilities along the Big Lost River. Two computer programs (the Culvert Analysis Program [CAP] and the HEC-RAS model) were used to define stage-discharge relations for 31 culverts and two bridge sites in a ten-mile reach of the river. These relations can be used to improve surface-water flow models to evaluate potential flooding.

Relations between headwater, tailwater, and discharge through each structure were unique. Discharge through the culverts, as computed by the CAP, ranged from about nine cubic feet per second to as much discharge as could be conveyed. Tailwater elevations ranged from about 0 to 30 feet above the outlet elevation. Discharge through the bridges, as computed by the HEC-RAS model, ranged from nearly 0 to 7000 cubic feet per second, and tailwater elevations ranged from nearly 0 to 30 feet above the stream bed on the downstream cross section of each bridge.

Stage-discharge relations provided in lookup tables in this report can be incorporated into numerical surface-water flow models to simulate the effects of hydraulic structures on flood flows. One limitation of the CAP and HEC-RAS models is that changes in flow conditions, such as obstruction by sediment and debris, are not simulated. If flow through a hydraulic structure is obstructed by sediment or debris, then model-simulated discharges through the structure might be greater than would be experienced under actual conditions.

Reevaluation of Background Iodine-129 Concentrations in Water From the Eastern Snake River Plain Aquifer, Idaho, 2003 *(Cecil, et. al. 2003)*

Background concentrations of iodine-129 (^{129}I, half-life = 15.7 million years) resulting from natural production in the earth's atmosphere, in situ production in the earth by spontaneous fission of uranium-238 (^{238}U), and fallout from nuclear-weapons tests conducted in the 1950s and 1960s were reevaluated on the basis of 52 analyses of ground- and surface-water samples collected from the Eastern Snake River Plain (ESRP) in southeastern Idaho. The background concentration estimated using the results of a subset of 30 groundwater samples analyzed in this reevaluation is 5.4 attocuries per liter (aCi/L; 1 aCi = 10^{-18} curies) and the 95-percent nonparametric confidence interval is 5.2 to 10.0 aCi/L. In a previous study, a background ^{129}I concentration was estimated on the basis of analyses of water samples from 16 sites on, or tributary to, the ESRP. At the 99-percent confidence level, background concentrations of ^{129}I in that study were less than or equal to 8.2 aCi/L.

During 1993 and 1994, 34 water samples from 32 additional sites were analyzed for ^{129}I to better establish the background concentrations in surface and ground water from the ESRP that is presumed to be unaffected by waste-disposal practices at the INEEL. Surface water contained larger ^{129}I concentrations than water from springs and wells contained. Because surface water is more likely to be affected by anthropogenic fallout and evapotranspiration, background ^{129}I concentrations were estimated in the current research using the laboratory results of groundwater samples that were assumed to be unaffected by INEEL disposal practices.

Estimating the Magnitude of the 100-Year Peak Flow in the Big Lost River at the Idaho National Engineering And Environmental Laboratory, Idaho *(Hortness and Rousseau 2003)*

Accurate estimates of peak flows in the Big Lost River at the INEEL are needed to assist planners and managers with evaluating possible effects of flooding on facilities at the INEEL. A large difference of 4350 cubic feet per second (ft^3/s) between two previous estimates of the magnitude of the 100-year peak flow in the Big Lost River near the western boundary of the INEEL prompted the present study.

Regression models that compared annual peak flows and attenuation of annual peak flows between successive gaging stations for the same flow event were used to estimate the magnitude of the 100-year peak flow in the Big Lost River. The 100-year peak flow of 4790 ft^3/s at the Howell Ranch gaging station was used as the starting point for this analysis. This estimate was determined by using a three-parameter log-Pearson Type III distribution as outlined in "Guidelines for Determining Flood Flow Frequency" (Bulletin 17B by the Interagency Advisory Committee on Water Data).

The regression models indicated that, in the reach of the Big Lost River between Howell Ranch and Mackay Reservoir, downstream peak flows are lower than upstream peak flows. Peak-flow attenuation values for this reach of the river decreased nonlinearly as the magnitude of the peak flow increased. Extrapolation of the trend resulted in an attenuation estimate of 13 percent for this reach relative to the 100-year peak flow at the Howell Ranch gaging station.

In the lower reach of the Big Lost River between Mackay Reservoir and Arco, downstream peak flows are also lower than upstream peak flows. However, in contrast to the upper reach, peak-flow attenuation values decreased linearly as the magnitude of the peak flow increased. Extrapolation of the data indicated that peak-flow attenuations in this reach of the river approach zero for flows approaching the 100-year peak flow estimate immediately upstream and downstream from Mackay Reservoir.

A regression model of annual maximum daily mean flows between Arco and the INEEL diversion dam indicated that the attenuation values in this reach of the river are nearly the same for all flows of record. Extrapolation of the linear regression of these values resulted in an attenuation estimate of 10 percent. Seepage measurements made during 1951-1953 also resulted in a loss estimate of approximately 10 percent. This attenuation value, combined with the values from analyses of the upstream reaches, resulted in an estimate of the 100-year peak flow for the Big Lost River immediately upstream from the INEEL diversion dam of 3750 ft^3/s; therefore, the upper and lower 95-percent confidence limits were 6250 and 1300 ft^3/s, respectively.

Localized rainfall, even of high intensity, is not likely to produce large peak flows at the INEEL because of high loss rates (infiltration, bank storage, and channel storage) along much of the stream channel. The relatively short flow durations resulting from rainstorms historically have not provided sufficient volumes of water to satisfy local storage demands (bank and channel storage). Only after these storage demands are met do the loss rates decrease enough for significant peak flows to reach the INEEL site.

An uncertain component of the present analysis is the effect of seismic activity on the 100-year peak-flow estimate. Analysis of the effect of the magnitude 7.3 Borah Peak earthquake in 1983 on normal flow conditions in the Big Lost River suggests that the joint occurrence of a large earthquake and a 100-year peak flow could significantly increase the magnitude of the peak flow at the INEEL.

Measurement of Sedimentary Interbed Hydraulic Properties and Their Hydrologic Influence Near the Idaho Nuclear Technology and Engineering Center at the Idaho National Engineering and Environmental Laboratory *(Perkins 2003)*

Disposal of wastewater to unlined infiltration ponds near the Idaho Nuclear Technology and Engineering Center (INTEC), formerly known as the Idaho Chemical Processing Plant, at the INEEL has resulted in the formation of perched water bodies in the unsaturated zone (Cecil et al., 1991). The unsaturated zone at the INEEL comprises numerous basalt flows interbedded with thinner layers of coarse- to fine-grained sediments and perched groundwater zones exist at various depths associated with massive basalts, basalt-flow contacts, sedimentary interbeds, and sediment-basalt contacts. Perched groundwater is believed to result from large infiltration events such as seasonal flow in the Big Lost River and wastewater discharge to infiltration ponds. Evidence from a large-scale tracer experiment conducted in 1999 near the Radioactive Waste Management Complex, approximately 13 km from the INTEC, indicates that rapid lateral flow of perched water in the unsaturated zone may be an important factor in contaminant transport at the INEEL (Nimmo et al., 2002). Because sedimentary interbeds, and possibly baked-zone alterations at sediment-basalt contacts (Cecil et al., 1991) play an important role in the generation of perched water, it is important to assess the hydraulic properties of these units.

In September 2001, the Vadose Zone Research Park (VZRP) was established near the INTEC for study of the movement of water and solutes through the unsaturated zone. Two new percolation ponds at the VZRP receive about a million gallons of equipment-cooling water each day. The subsurface at this location is much more complex than that near the RWMC and little is known about the hydraulic properties of the sedimentary interbeds. As part of an ongoing sedimentary interbed characterization project, hydraulic properties, including saturated and unsaturated hydraulic conductivity and water retention, were measured on 12 cores recovered from two interbeds from borehole ICPP-SCI-V-215 in the vicinity of the INTEC, which was drilled by the U.S. Geological Survey (USGS) as a part of the development of the VZRP.

In general, the upper interbed examined in this study exhibits hydraulic properties consistent with higher clay contents than those of the lower interbed and also contains low-permeability layers that could enhance perching. These interbeds, which are separated by a relatively thin basalt flow, also exhibit distinctly different baked-zone features that are apparent from visual and scanning electron microscope examination. Heat exposure from overlying lava flows produces baked zones at the tops of interbeds due to the dehydration and oxidation of iron-rich minerals. The baked zone of the upper interbed is macroporous, containing highly cemented aggregates, while the baked zone of the lower interbed contains highly-oxidized, mainly unconsolidated sand. Baked-zone sediments from both interbeds, although texturally and structurally different, have comparable, relatively high saturated hydraulic conductivities.

In order to quantify the effect of the macro-porous structure of the baked material in the upper interbed, water retention was measured on two undisturbed cores in addition to the 12 cores used for hydraulic property measurements. Water retention measurements were performed on the two undisturbed cores, the cores were air dried, disaggregated, and repacked for additional measurements in order to identify any structural effects.

A Conceptual Model of Flow in the Snake River Plain Aquifer at and near the Idaho National Engineering and Environmental Laboratory, with Implications for Contaminant Transport *(Rousseau et al. 2003)*

A 50-year history of waste disposal associated with nuclear-reactor research and nuclear-fuel processing at the INEEL in southeast Idaho has resulted in measurable concentrations of radioactive and chemical contaminants in the Snake River Plain Aquifer. A thorough understanding of the movement and fate of these contaminants in the subsurface is needed by the DOE and the State of Idaho to minimize health and safety risks, and to plan effectively for remediation activities. To achieve this understanding, a conceptual model has been developed as the foundation for numerical models that simulate flow and contaminant transport in the aquifer.

Volcanology, Geochemistry, and Stratigraphy of the F Basalt Flow Group, Eastern Snake River Plain, Idaho *(Scarberry 2003)*

The ESRP volcanic basin in southeast Idaho is underlain by approximately 1 km of dominantly Pliocene-Quaternary olivine tholeiite basalt and interbedded sediment. The F basalt flow group is a stratigraphic marker bed near the top of the regional aquifer and underlies a portion of the INEEL, where radiochemical and chemical wastewater has been discharged to the aquifer. This flow group erupted during an unusual, short-lived period of reversed magnetic polarity approximately 565 ka, probably in less than or equal to 200 years. This study uses new petrographic, geochemical, and isotopic analyses of the flow group to refine the subsurface stratigraphy. This sequence of lava flows is uneroded, apparently comagmatic, and is observed in drill core over an area of approximately 75 km^2 between approximately 120 to 220 m depth. Lithologic logs for six sections of F flows in drill-core reveal textural discordance within the sequence and that the thickest (approximately 55 m) lie in the southwest part of the study region and contain the upper portion (approximately 15 to 23 m) that is texturally coarser and significantly enriched in incompatible elements relative to the remainder of the sequence. In addition, lava flows in the lower sequence have lower initial strontium-87/strontium-86 isotopic ratios than the upper flows (0.7068 versus 0.7071) while all exhibit similar neodymium-143/neodymium-144 isotope ratios (approximately 0.5124; $epsilon_{Nd}$ approximately -4.3). Petrographic, isotopic, and geochemical features support correlations between sampled sections and define two flow groups within the F sequence. Variations in the texture and stratigraphy of the two flow groups indicate that they were derived from multiple coeval eruptive centers aligned along a common rift or fissure system, and not from a central vent complex. The stratigraphy of the entire F sequence is consistent with formation by constructional volcanic processes and is unaffected by post depositional structural offsets.

Geochemical Modeling of the Little Lost River and Birch Creek Drainage Basins *(Swanson 2003)*

The USGS and Idaho State University, in cooperation with the DOE, are conducting studies to describe the chemical character of groundwater that moves as underflow from drainage basins into the SRPA system at, and near, the INEEL and the effects of these recharge waters on the geochemistry of the SRPA system. Each of these recharge waters has a hydrochemical character related to geochemical processes, especially water-rock interactions that occur during migration to the SRPA. Results of these studies will benefit ongoing and planned geochemical modeling of the SRPA at the INEEL by providing model input on the hydrochemical character of water from each drainage basin.

For this study, water samples were collected from six wells and two surface sites from the Little Lost River drainage basin during 2000. The samples were analyzed for selected inorganic constituents, dissolved organic carbon, stable isotopes, tritium, and selected gross measurements of radioactivity. Four duplicate samples were collected for quality assurance. Results show that most water from the Little Lost River drainage basin has a calcium-magnesium bicarbonate character. Two wells had elevated chloride concentrations. The computer code NETPATH was used to evaluate geochemical mass-balance reactions in the Little Lost River basin. Attempts to model water to the most downgradient wells, Mays and Ruby Farms, were unsuccessful. On closer inspection of these two wells, it was determined that they were much deeper than the other sample locations and that they may have chemical interaction with the SRPA. It was also apparent that another of the sample locations had contamination due to local agricultural practices. One well had concentrations that mirrored Little Lost River water. Of all the sites sampled, only two upgradient wells had water representative of the system. Mass-balance modeling of the system identified that the dissolution of dolomite was the major reaction taking place in the system. Nitrification of ammonium ion to nitrate and dissolution of inorganic fertilizers also are chemical processes that occur in the system. To obtain a better geochemical model for the Little Lost River drainage basin more sites need to be sampled, paying close attention to the type of well that is being sampled and the agricultural practices in the surrounding area.

Water samples were collected from five wells and one surface site from the Birch Creek drainage basin during 2000. The samples were analyzed for selected inorganic constituents, dissolved organic carbon, stable isotopes, tritium, and selected gross measurements of radioactivity. Four duplicate samples were collected for quality assurance. Results show that most water from the Birch Creek drainage basin has a calcium-magnesium bicarbonate character.

The Birch Creek Valley can be roughly divided into three hydrologic areas. The northern part of the valley, where groundwater is forced to the surface by a basalt barrier and the sampling sites are either surface water or shallow wells. This area has a water chemistry that can be characterized by simple evaporation models, simple calcite-carbon dioxide models, or by complex models involving carbonate and silicate minerals. The central part of the valley is filled by sedimentary material and the sampling sites are wells that are deeper than the northern part. This area has a water chemistry that can be characterized by simple calcite-dolomite-carbon dioxide models. The southern part is where the groundwater enters the SRPA. In this area, the sampling sites are wells with depths and water levels much deeper than the northern and central parts of the Birch Creek Valley. The calcium and carbon water chemistry in this area can be characterized by a simple calcite-carbon dioxide model, but more complex calcite-silicate models do a better job of accounting for mass transfer in these areas.

Throughout the system, calcite precipitates if it is an active phase. Carbon dioxide can either precipitate (outgas) or dissolve depending on the partial pressure of carbon dioxide in water from the modeled sites. Dolomite was only an active phase in models from the central part of the system. Generally, the entire system can be modeled with either evaporative models, carbonate models, or carbonate-silicate models. Both of the latter types of models generally have a significant amount of calcite precipitation relative to the mass transfer to and from the other active phases. The precipitation of calcite in the more complex models is consistent with the amount of calcite precipitated in the simpler models. This suggests that although the simpler models easily predict calcium and carbon concentration in Birch Creek Valley ground and surface water, silicate mineral based models are required to account for other constituents. The amount of mass transfer to and from the silicate mineral phases is generally small compared to the carbonate phases. It appears that the water chemistry of USGS 126B is representative of water recharging the SRPA by means of underflow from the Birch Creek Valley.

Radiochemical and Chemical Constituents in Water From Selected Wells and Springs From the Southern Boundary of the Idaho National Engineering and Environmental Laboratory to the Hagerman Area, Idaho, 2001 *(Twining et al. 2003)*

The USGS and the Idaho Department of Water Resources, in cooperation with the DOE, sampled water from 16 of 18 sites as part of the fifth round of a long-term project to monitor water quality of the SRPA from the southern boundary of the INEEL to the Hagerman area. The samples were collected from eight irrigation wells, four domestic wells, two stock wells, one spring, and one public supply well and analyzed for selected radiochemical and chemical constituents. Two sites were not sampled because one was decommissioned and the other was discontinued due to complications with a new well owner. Two quality assurance replicate samples were also collected and analyzed. Tritium analyses from 19 spring samples collected along the Snake River in the Twin Falls-Hagerman area also are presented within this report along with two replicate quality assurance samples.

None of the reported radiochemical or chemical constituent concentrations exceeded the established maximum contaminant levels for drinking water. Many of the radionuclide and inorganic constituent concentrations were greater than the respective minimum reporting levels. Most of the organic constituent concentrations were less than the minimum reporting levels.

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